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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

IN RE APPLICATION OF: HENRIK GLENT-MADSEN

FOR: LIGHT MODULATING ENGINE

CLAIM FOR PRIORITY

The Commissioner of Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Applicant hereby claims the benefit of the filing date of April 9, 2002 of Danish Patent Application No. PA 2002 00516 under the provisions of 35 U.S.C. 119 and the International Convention for the Protection of Industrial Property.

If any fees are due with regard to this claim for priority, please charge them to Deposit Account No. 06-1130 maintained by Applicant's attorneys.

Respectfully submitted,

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Title: Light modulating engine
IPC: -
The attached documents are exact copies of the filed application

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09 May 2003

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PATENT- OG VAREMÆRKESTYRELSEN

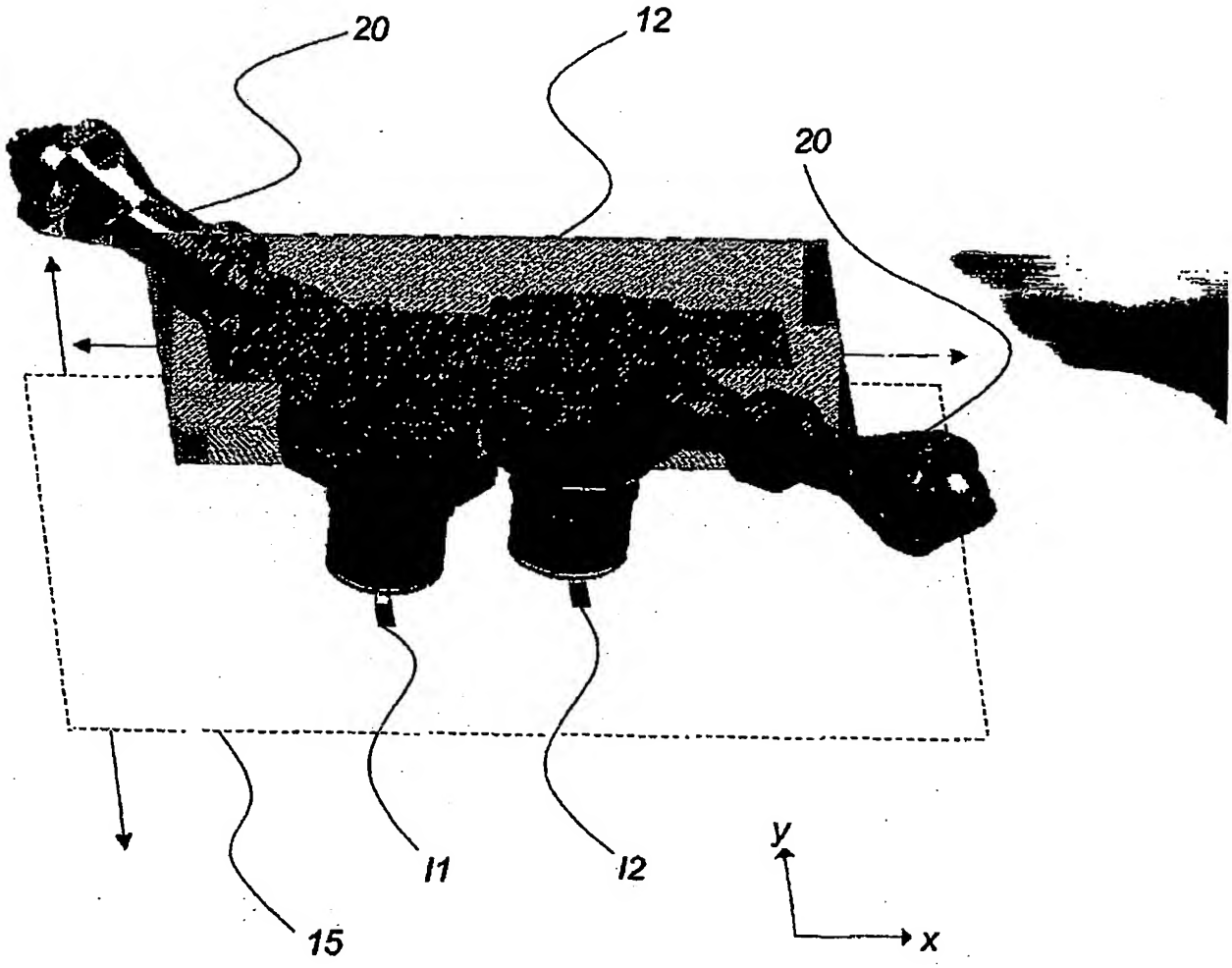

Fig. 1

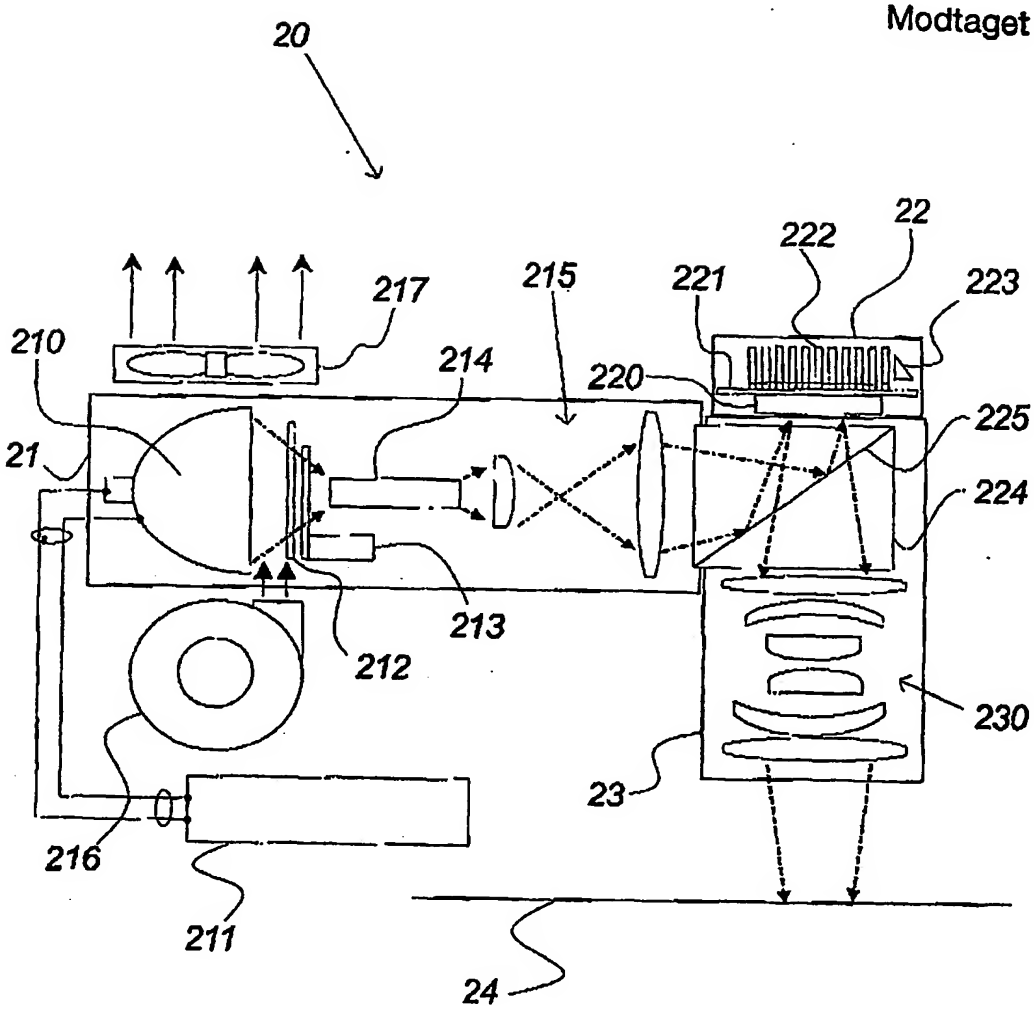

Fig. 2

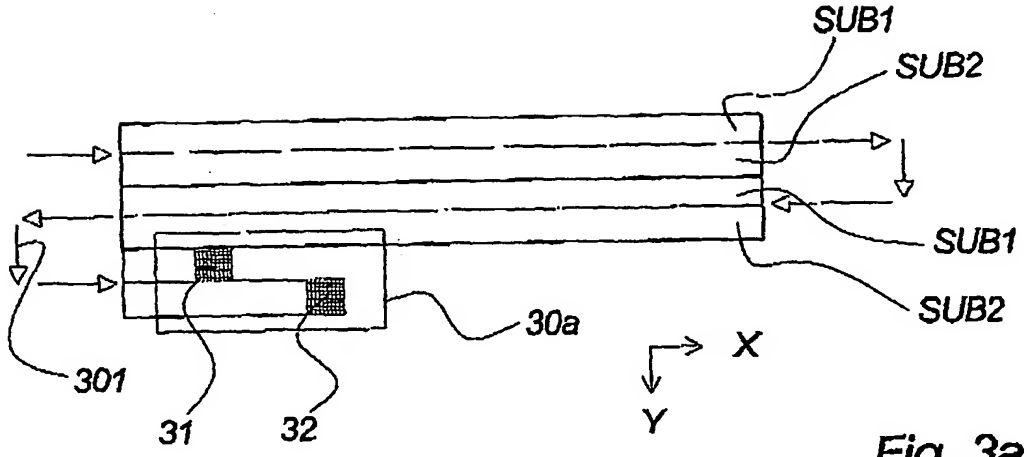

Fig. 3a

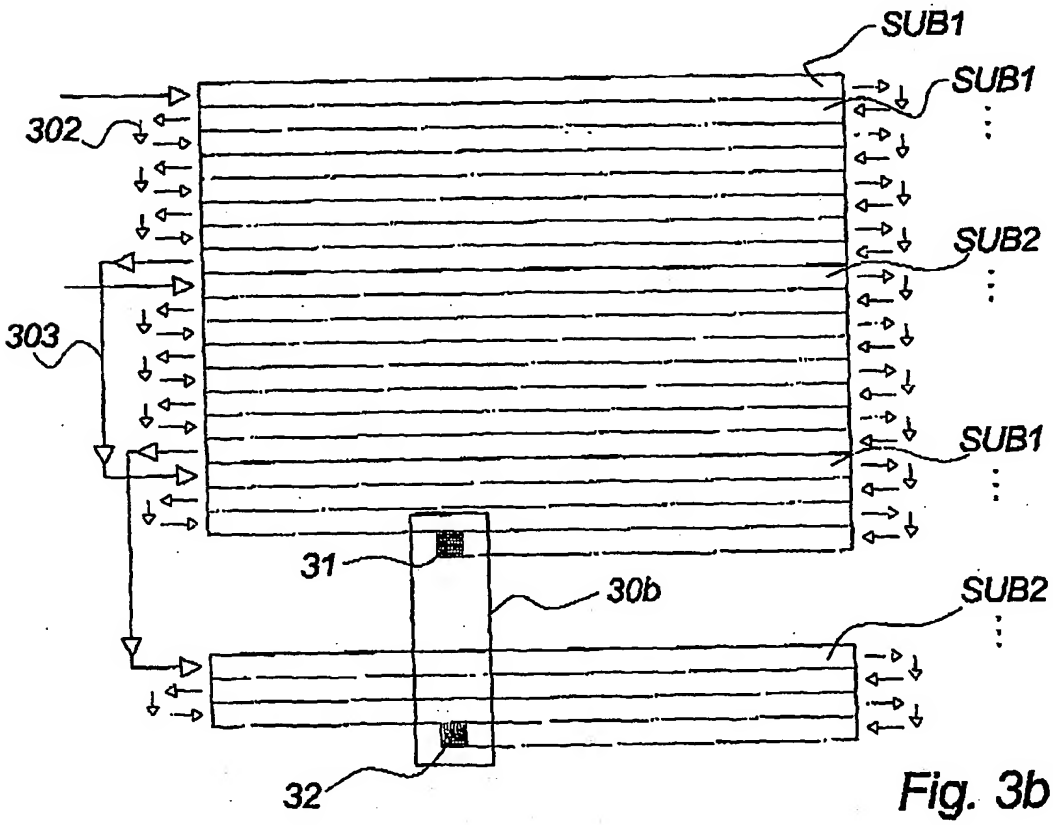

Fig. 3b

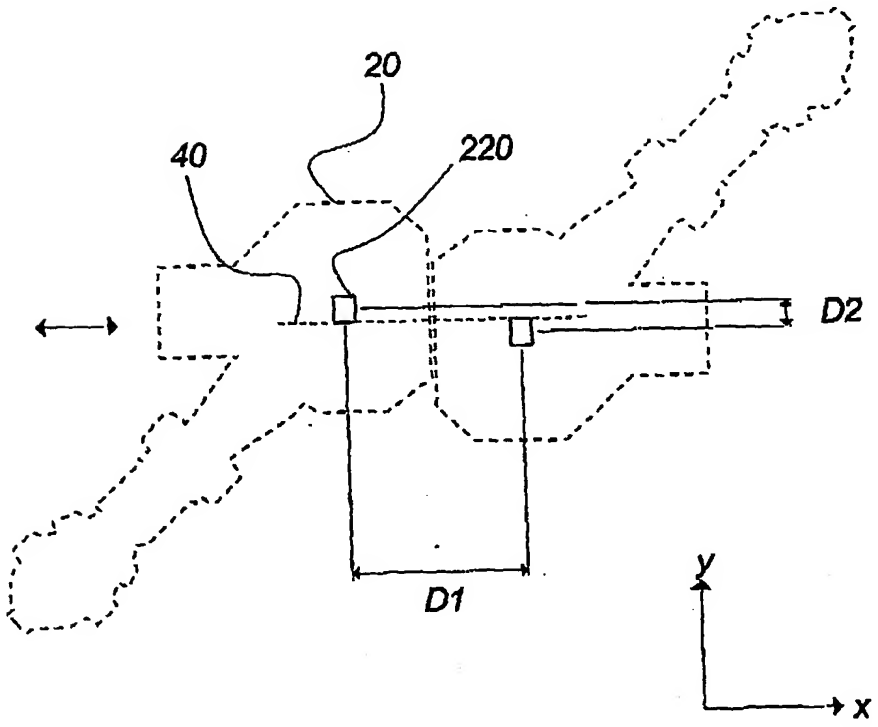

Fig. 4

LIGHT MODULATING ENGINE

Field of the invention

The present invention relates to a light illumination apparatus according to claim 1.

Background of the invention

Typically, exposure systems comprises one spatial light modulator or a high number of spatial light modulators.

Summary of the invention

The invention relates to a light illumination apparatus comprising at least one exposure head comprising two light modulating arrangements ,

each of said two light modulating arrangements comprising a spatial light modulator and an associated light emitter arranged for illumination of an illumination surface via said spatial light modulator

each of said two light modulating arrangements being digitally controlled,

said exposure head being movable in at least one direction with respect to said illumination surface.

According to the invention it has been realised that a movable exposure head may advantageously comprise two spatial light modulators, thereby facilitating a scanning by means of a two modulators at one time.

Hence, experiments has revealed that traditional scanning by means of one spatial light modulator only, does not meet the necessary overall scanning speed requirements. However, in practice, it has been difficult to obtain real advantages when applying more than two spatial light modulators because the hardware

associated to the spatial light modulator results in quite heavy light modulating arrangements.

When said spatial light modulators being arranged so as to illuminate two substantially separate sub-areas of said illumination surface , an advantageous embodiment of the invention has been obtained.

When said spatial light modulating arrangements being aligned so that the rows of the both light modulators parallel oriented, an advantageous embodiment of the invention has been obtained.

When said spatial light modulating arrangements being aligned so that the neighbouring rows of the two spatial light modulators are positioned substantially so that the distance (DN) between the two neighbouring rows of the two spatial light modulators are substantially the same as the distance (DR) between the rows of the individual light modulators, an advantageous embodiment of the invention has been obtained.

When the "x-projection" (D1) of the distance between the centres of the two spatial light modulators being less than 200 millimetres, preferably less than 150 millimetres, preferably substantially 120 millimetres, an advantageous embodiment of the invention has been obtained.

When the "y-projection" (D2) of the distance between the centres of the two spatial light modulators being less than 50 millimetres, preferably less than 35 millimetres, preferably substantially 25.6 millimetres or 20.5 millimetres when applying SXGA, and XGA respectively, an advantageous embodiment of the invention has been obtained.

When the distance between the centres of the two spatial light modulators being less than 121.73 milimetres (XGA) or 122,70 milimetres (SXGA), an advantageous embodiment of the invention has been obtained.

According to the invention it has been recognised that a very close positioning of the light modulating arrangements facilitate an improved overall scanning speed in the sense that the effective scanning area is optimised. A minimising of the distance therefore results in that both spatial light modulators of the exposure head are active as long as possible at the ends of the scanning lines.

When said exposure head comprising cooling means , an advantageous embodiment of the invention has been obtained.

Cooling means may e.g. comprise electrically driven fans.

When each spatial light modulating arrangement comprising individual cooling means , an advantageous embodiment of the invention has been obtained.

When said substantially separate sub-areas comprising neighbouring surfaces of said illumination surface , an advantageous embodiment of the invention has been obtained.

When said at least one direction being substantially transverse to a relative movement of said illumination surface , an advantageous embodiment of the invention has been obtained.

When said at least one direction establishing that an illuminated pixel on said illumination is illuminated by means of a least two light modulator of said spatial light modulator, an advantageous embodiment of the invention has been obtained.

When said at least one direction establishing that an illuminated pixel on said illumination is illuminated by means of at least one modulator row of said spatial light modulator, an advantageous embodiment of the invention has been obtained.

When said exposure head being movable in at least two directions with respect to said illumination surface, an advantageous embodiment of the invention has been obtained.

When said light emitter comprising a light source , an advantageous embodiment of the invention has been obtained.

When said light emitter comprising at least on light emitting end of a optical guide coupled to a light source, an advantageous embodiment of the invention has been obtained.

When said light emitter comprising a lamp, an advantageous embodiment of the invention has been obtained.

When said light emitter comprising a LED matrix, an advantageous embodiment of the invention has been obtained.

When said spatial light modulator comprising a DMD chip, an advantageous embodiment of the invention has been obtained.

The spatial light modulating array of the illumination arrangements may be a transmissive micro-mechanical shutter array as disclosed in WO 98 47048 and WO 98 47042 which are hereby included by reference.

Another type of spatial modulator may be a DMD modulator or e.g. LCD light modulator.

When said spatial light modulator comprising a micro-mechanical transmissive light modulator, an advantageous embodiment of the invention has been obtained.

When said illumination surface comprising a printing plate, an advantageous embodiment of the invention has been obtained.

When said illumination surface comprising a light sensitive material, such as epoxy, an advantageous embodiment of the invention has been obtained.

According to the invention, the illumination arrangement may be applied for socalled rapid prototyping.

The figures

The invention will be described in the following with reference to the drawings where

fig. 1 illustrates a view of a exposure systems according to an advantageous embodiment of the invention,

fig. 2 illustrates a cross-section of a illuminating arrangement according an embodiment of the invention,

fig. 3a illustrates a scanning pattern of a exposure head with respect to an illumination surface and where

fig. 3b illustrates a further scanning pattern of a exposure head with respect to an illumination surface and where

fig. 4 illustrates an advantageous positioning of the illuminating arrangements on the exposure head.

Detailed description

Fig. 1 illustrates a view of a few main components of an exposure systems according to an advantageous embodiment of the invention.

The illustrated system comprises an exposure head 12 comprising two illumination arrangements 20 arranged for illumination of an illumination surface 15. The exposure head 12 is suspended in a suspension (not shown). The suspension facilitates movement in the direction of the arrows under control by suitable electronic circuits (not shown).

For illustrative purposes, two illumination areas I1, I2 illuminated by the spatial light modulators (e.g. DMD chips) arranged in the illumination arrangements 20 are indicated on the illumination surface. The illumination areas I1 and I2, may e.g. comprise 1024x768 (XGA) pixels or 1280 x1024 pixels (SXGA) if applying e.g TI DMD-chips. The modulated pixels will, if applying a scanning movements be switched dynamically from row to row (or column to column) thereby applying several pixels (e.g. a complete row of a spatial light modulator) for illumination of a single pixel on the illumination surface. Thereby, the delivered optical energy to a single pixel is increased.

According to the illustrated embodiment, the exposure head is moved in the X-direction and the illumination surface 15 is moved stepwise in the Y-direction.

Evidently, other relative movements may be applied within the scope of the invention. A further advantageous embodiment of the invention may e.g. imply a relative movement of the exposure head 12 in both directions X and Y while keeping the illumination surface stationary.

The spatial light modulating array of the illumination arrangements may be a transmissive micro-mechanical shutter array as disclosed in WO 98 47048 and WO 98 47042 which are hereby included by reference.

Another type of spatial modulator may be a DMD modulator.

Fig. 2 illustrates a preferred embodiment of one of the light modulating arrangements 20 of figure 1. The first part 21 of the arrangement 20 produces a focused and uniform beam of light. It comprises a lamp 210, a lamp driver 211, a blower 216 and a fan 217, a protection glass 212, a shutter 213, a light-integrating rod 214 and beam shaping optics 215.

The type of lamp 210 depends on the type of plate to be exposed. Possible types comprise conventional short arc bulbs, laser sources, diode arrays and more. A preferred conventional lamp might have a power consumption of 160 W, but the present invention is not in any way limited to this value, nor to the mentioned types of lamps.

The light from the lamp 210 is transmitted through a filter (e.g. IR or UV- filter depending on the application) 212, functioning as an interference filter, and through a shutter mechanism 213, making it possible to turn off the light beam without turning off the lamp. This is important as most lamp types need time before their light intensity and frequency is unvarying. A blower 216 and a fan 217 ensure the cooling of the lamp 210.

Next the light beam is sent through a light-integrating rod 214. This mixes the light, making the light throughout the beam uniform with regards to intensity and direction. This ensures that the light in the periphery of the beam has the same intensity as the light in the center of the beam. When the light leaves the light-integrating rod 214, the beam shaping optics 215 focuses it.

The next part of the arrangement 20 modulates the light beam to reflect electronically stored image data. It comprises a light-modulating means 22 and means 224 for directing the unmodulated light beam towards the light-modulating means 22 without disturbing its modulated light beam output.

Suited light-modulating means 22 comprises DMD modulators, transmissive shutters including LCD and micro-mechanical shutters, and more. For the preferred embodiment of figure 2, a DMD light-modulating chip 220 mounted on a PCB 221 with a cooling plate 222 and a temperature sensor 223 is used.

The light directing means 224 depends on the type of light-modulating means 22 used. For transmissive light modulating means the unmodulated light beam is directed towards one side of the light modulating means, and the modulated light beam is emitted from the other side. In such an arrangement the light directing means 224 might be excluded.

For DMD modulators the unmodulated light beam is directed towards the same point as where the modulated light beam is emitted. This necessitates the use of light directing means 224. In the preferred embodiment of figure 2 a TIR-prism is used for light directing means. TIR is an abbreviation meaning 'Total Internal Reflection'. A TIR-prism comprises a surface 225 which will act as a mirror to light coming from one direction (from the left for this specific embodiment), and will let light coming from an other direction (from the top for this specific embodiment) straight through.

The last part of the arrangement 20 focuses the multiple modulated light beams emitted from the light modulating means 220 on the exposure plate 24 (printing plate) . It comprises a set of lenses / a macro lens 230 located within a housing 23.

Fig. 3a illustrates a scanning pattern of a exposure head with respect to an illumination.

The illustrated scanning pattern obtained by the light illumination apparatus according to the invention involves that the two illuminating arrangements of an exposure head performs a relative movement with respect to an illumination surface.

One of the illustrated illuminating heads illuminates the sub areas SUB1 and the other illuminates the sub areas SUB2.

It should be noted that the exposure head 30a illuminates the illumination surface by modulated light in both directions.

The y-axis movement is here performed as steps corresponding to the total transverse scanning width obtained by both light illuminating arrangements in combination.

Fig. 3b illustrates a further scanning pattern of a exposure head with respect to an illumination surface.

According to the illustrated embodiment of the invention, an exposure head 30b comprises two spatial light modulators 31, 32 (the illumination arrangements carrying the spatial modulators are not illustrated). According to the illustrated embodiment two spatial light modulators 31, 32 (or the resulting illuminated surface corresponding to I1, and I2 of fig. 1) are arranged and displaced only in the Y-direction.

The exposure head is performing a scanning movement back and forth in the X-direction. Moreover, the illumination surface or the exposure head performs a relative movement in the Y-direction involving basically two different steps, a microstep 302 and a macro step 303.

According to the illustrated embodiment eight sub-areas SUB1 and eight sub-areas SUB2 are illuminated by performing the micro-steps 302. Thereafter, a macro step 303 is performed and a new set of sub-areas SUB1 and SUB2 are illuminated by performing further microsteps 302.

It should be emphasized that several other scanning method (patterns) may be applied within the scope of the invention.

Fig. 4 illustrates an advantageous positioning of the illuminating arrangements (here = optical engines) on the exposure head.

The dimensions of the optical engine are very important for the productivity and cost of the machine. The two illuminating arrangements of the exposure head are placed in order that the two obtainable images are adjacent in the y-axis (not to be confused with the scanning and modulator axis. This implies that there is a centre distance between the optical engines in the x-axis, see figure 4.

The spread of the engines in the x-axis implies that it is necessary to expose longer that the actual plate length so that both heads have passed the entire plate, the over scan is twice the centre distance. This over scan reduces the productivity and increases the width of the x-movement and thus the machine. The centre distance must therefore be as low as possible.

Centre distance, x-axis: D1=120 mm
Centre distance, y-axis: D2= (XGA) 20.48 ± 0.002 mm and D2 (SXGA) = 25.6 ± 0.002 mm

The interface is the round macro lens house with a flange. A fixture will allow adjustment in the printing plane, i.e. adjustment in x- and y-axis, and rotation about the z-axis, of the optical engines individually.
This implies that the image must be accurately parallel to the flange of the macro lens house, so that both images will be in the same plane.
The flange on the house is used to mount the house to the fixture, in the z direction. The bottom side of the flange will define the focus, so that the optical engines can be mounted against a flat surface, and thus having focus in the same plane.

(note that the illustrated x,y-axis does not correspond to the x-y-axis' orientation of the other figures, but represents a -45 ° inclined coordinated system with respect to for example the coordinate system of fig. 1.

Patent Claims

1. Light illumination apparatus comprising at least one exposure head (12) comprising two light modulating arrangements (20,

each of said two light modulating arrangements (20) comprising a spatial light modulator (31, 32) and an associated light emitter arranged for illumination of an illumination surface (15) via said spatial light modulator (31, 32)

each of said two light modulating arrangements 20) being digitally controlled,

said exposure head being movable in at least one direction (x;y) with respect to said illumination surface (15).

2. Light illumination apparatus according to claim 1, wherein
said spatial light modulators being arranged so as to illuminate two substantially separate sub-areas (SUB1, SUB2) of said illumination surface (15).

3. Light illumination apparatus according to claim 1 or 2, wherein
said spatial light modulating arrangements (31, 32) being aligned so that the rows of the both light modulators are parallel oriented

4. Light illumination apparatus according to any of the claims 1 to 3, wherein
said spatial light modulating arrangements (20) being aligned so that the neighbouring rows of the two spatial light modulators are positioned substantially so that the distance (DN) between the two neighbouring rows of the two spatial light modulators are substantially the same as the distance (DR) between the rows of the individual light modulators.

5. Light illumination apparatus according to any of the claims 1 to 4, wherein

the "x-projection" (D1) of the distance between the centres of the two spatial light modulators being less than 200 millimetres, preferably less than 150 millimetres, preferably substantially 120 millimetres.

6. Light illumination apparatus according to any of the claims 1 to 5, wherein the "y-projection" (D2) of the distance between the centres of the two spatial light modulators being less than 50 millimetres, preferably less than 35 millimetres, preferably substantially 25.6 millimetres or 20.5 millimetres when applying SXGA, and XGA respectively.

7. Light illumination apparatus according to any of the claims 1 to 6, wherein the distance between the centres of the two spatial light modulators being preferably substantially 122.7 millimetres or 121.73 millimetres when applying SXGA, and XGA respectively.

8. Light illumination apparatus according to any of the claims 1 to 7, wherein said exposure head comprising cooling means (216, 217).

9. Light illumination apparatus according to any of the claims 1 to 8, wherein each spatial light modulating arrangement comprising individual cooling means (216, 217).

10. Light illumination apparatus according to any of the claims 1 to 9, wherein said substantially separate sub-areas (SUB1, SUB2) comprising neighbouring surfaces of said illumination surface (15)

11. Light illumination apparatus according to any of the claims 1 to 10, wherein said at least one direction being substantially transverse to a relative movement of said illumination surface (15)

12. Light illumination apparatus according to any of the claims 1 to 11, wherein

said at least one direction establishing that an illuminated pixel on said illumination is illuminated by means of a least two light modulator of said spatial light modulator.

13. Light illumination apparatus according to any of the claims 1 to 12, wherein said at least one direction establishing that an illuminated pixel on said illumination is illuminated by means of at least one modulator row of said spatial light modulator.

14. Light illumination apparatus according to any of the claims 1 to 13, wherein said exposure head being movable in at least two directions with respect to said illumination surface.

15. Light illumination apparatus according to any of the claims 1 to 14, wherein said light emitter comprising a light source (210).

16. Light illumination apparatus according to any of the claims 1 to 15, wherein said light emitter comprising at least on light emitting end of a optical guide coupled to a light source.

17. Light illumination apparatus according to any of the claims 1 to 16, wherein said light emitter comprising a lamp.

18. Light illumination apparatus according to any of the claims 1 to 17, wherein said light emitter comprising a LED matrix.

19. Light illumination apparatus according to any of the claims 1 to 18, wherein said spatial light modulator comprising a DMD chip.

20. Light illumination apparatus according to any of the claims 1 to 19, wherein said spatial light modulator comprising a micro-mechanical transmissive light modulator.

21. Light illumination apparatus according to any of the claims 1 to 20, wherein

said illumination surface comprising a printing plate.

22. Light illumination apparatus according to any of the claims 1 to 21, wherein said illumination surface comprising a light sensitive material, such as epoxy.

23. Light illumination apparatus according to any of the claims 1 to 22, wherein the exposure head is adapted for scanning in two transverse opposite directions.

24. Light illumination apparatus according to any of the claims 1 to 23, wherein the x-direction between centres of the spatial light modulating arrangement is less than 150 mm, preferably less than 121 mm.

25. Light illumination apparatus according to any of the claims 1 to 24, wherein the x-direction between centres of the spatial light modulating arrangement is substantially 0 (zero).

Abstract

The invention relates to a light illumination apparatus comprising at least one exposure head (12) comprising two light modulating arrangements (20),

each of said two light modulating arrangements (20) comprising a spatial light modulator (31, 32) and an associated light emitter arranged for illumination of an illumination surface (15) via said spatial light modulator (31, 32)

each of said two light modulating arrangements (20) being digitally controlled,

said exposure head being movable in at least one direction with respect to said illumination surface.